United States Patent [19]

Campbell

[11] **3,821,479**

[45] **June 28, 1974**

[54] **NONINTERFERING ELECTRICAL SIGNALING**

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[22] Filed: **Apr. 16, 1973**

[21] Appl. No.: **351,660**

[52] **U.S. Cl.** ..... **179/15 BF**

[51] **Int. Cl.** **H04j 1/16**

[58] **Field of Search** ..... 179/15 BF, 15 AL

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[57] **ABSTRACT**

An electrical protection circuit having at least one line circuit, the line circuit consisting of a plurality of data transmitters and data receivers, is described. The data transmitters are connected in parallel across a transmission path and operate in a frequency multiplexing mode. The data receivers at a central supervisory station are connected in parallel and a deviation from normal at any of the data transmitters is recorded and stored in input circuits at the central supervisory station. A return to normal is similarly recorded and stored. The input circuits are sequentially scanned and messages are printed corresponding to the state of the input circuit. The system includes fault detecting and alarm circuitry which conditions the line circuit when a break occurs. A programmer dircuit connected to the printer provides a unique message cofresponing to each input circuit. Time discriminator units at the monitor station and the central supervisory station are provided to enable a single tone transmitter to indicate the condition of a momentary actuating device and an extended time actuating device.

14 Claims, 5 Drawing Figures

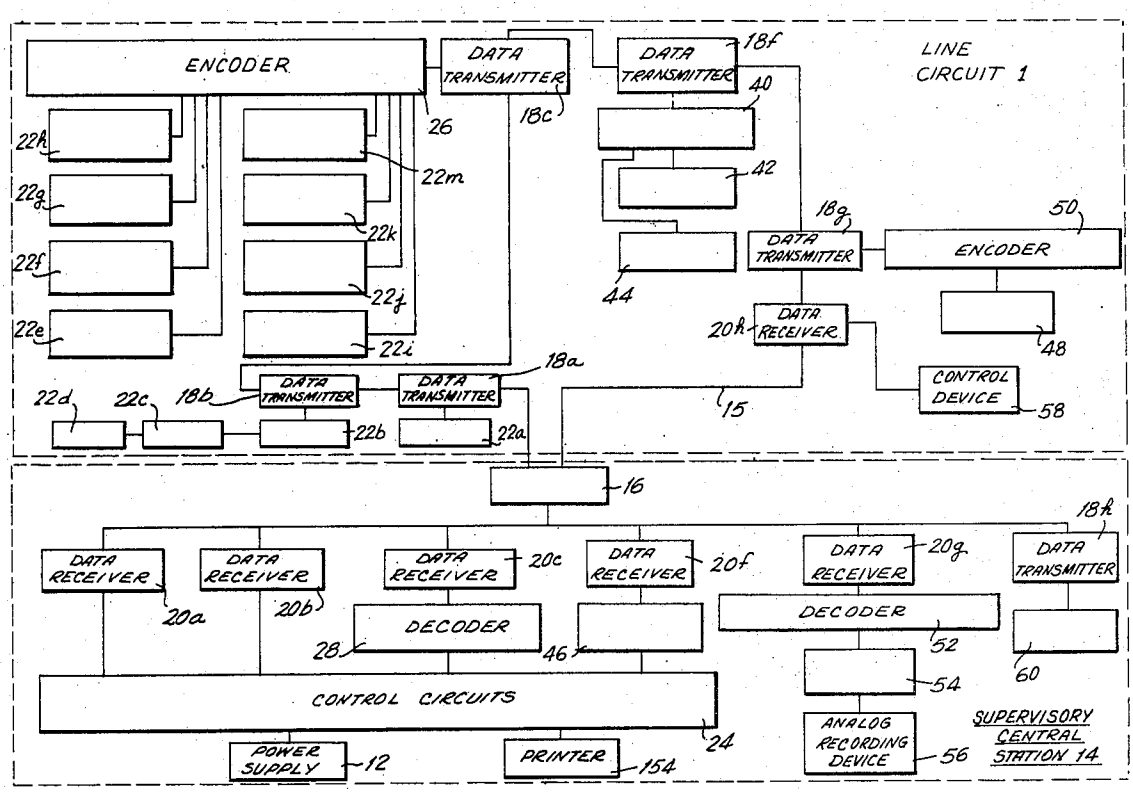


FIG. 1

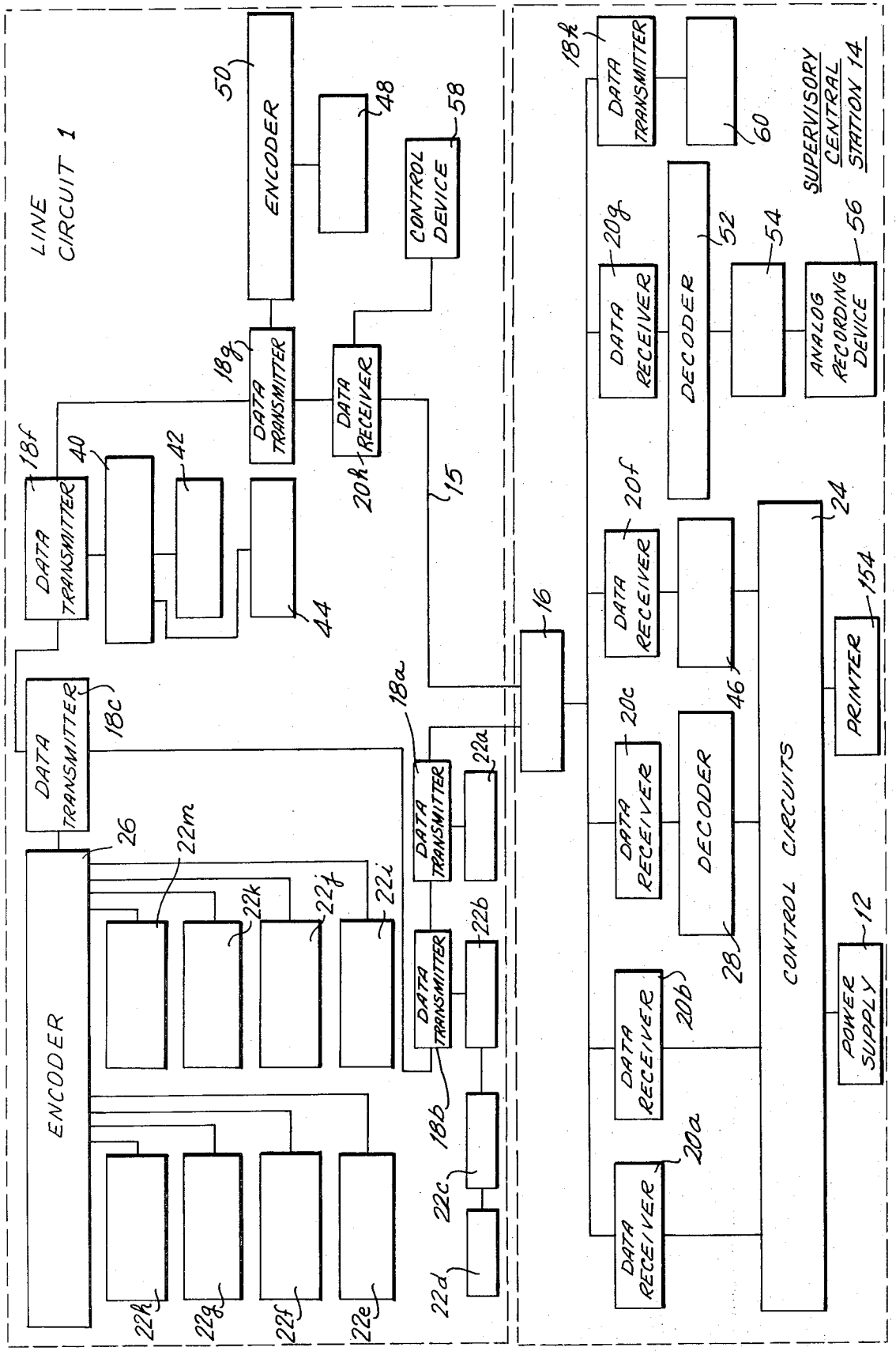
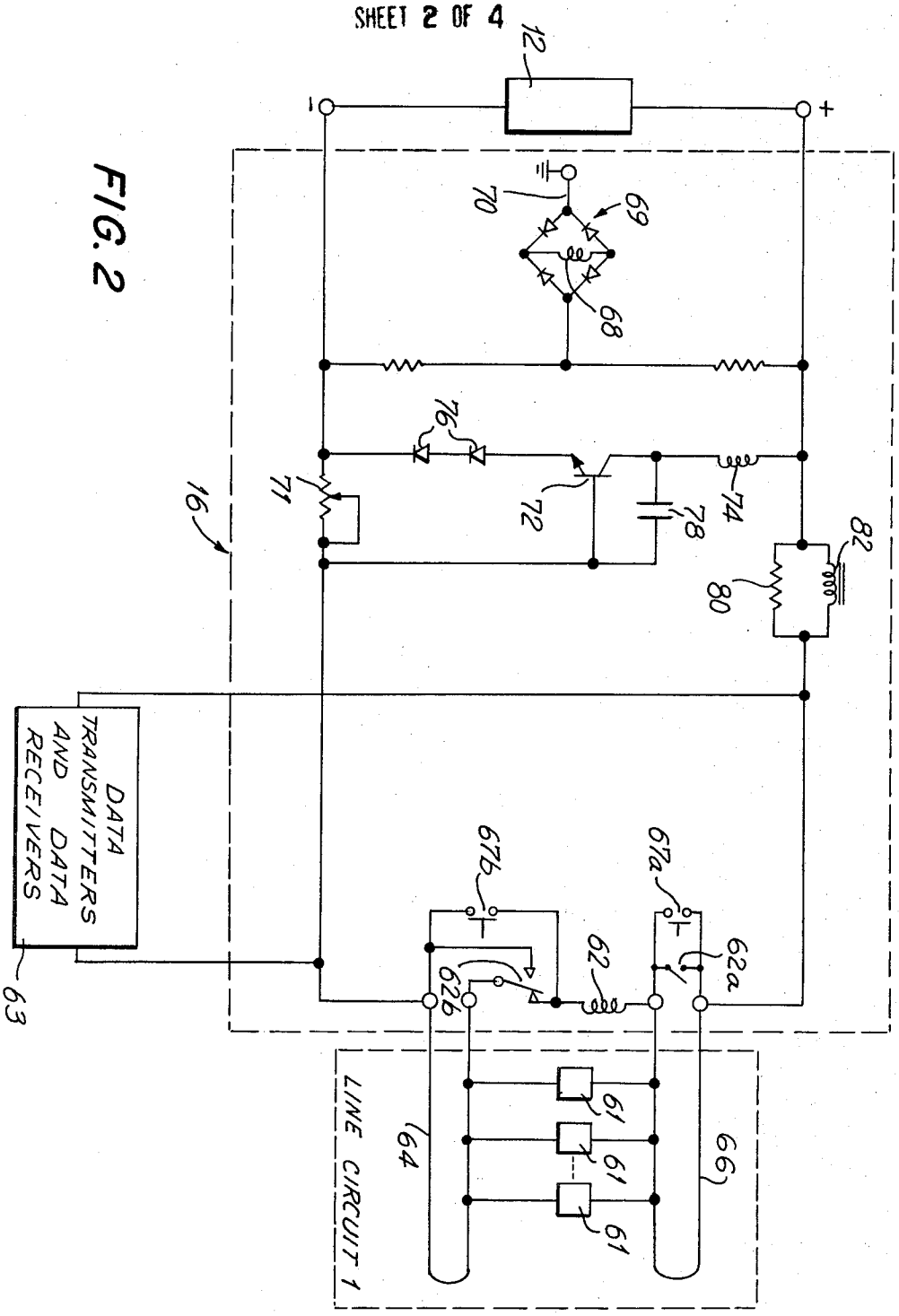

LINE CIRCUIT 1
SUPERVISORY CENTRAL STATION 14
ENCODER
DATA TRANSMITTER
DATA RECEIVER
DECODER
CONTROL CIRCUITS
POWER SUPPLY
PRINTER
ANALOG RECORDING DEVICE
CONTROL DEVICE
12
15
16
18a
18b
18c
18f
18g
18k
20a
20b
20c
20f
20g
20k
22a
22b
22c
22d
22e
22f
22g
22h
22i
22k
22m
24
26
28
40
42
44
46
48
50
52
54
56
58
60
154

FIG. 2


12
-
+
70
69
68
76
71
72
74
78
82
80
16
DATA TRANSMITTERS AND DATA RECEIVERS
63
67b
67a
62a
62
62b
61
61
61
64
66
LINE CIRCUIT 1

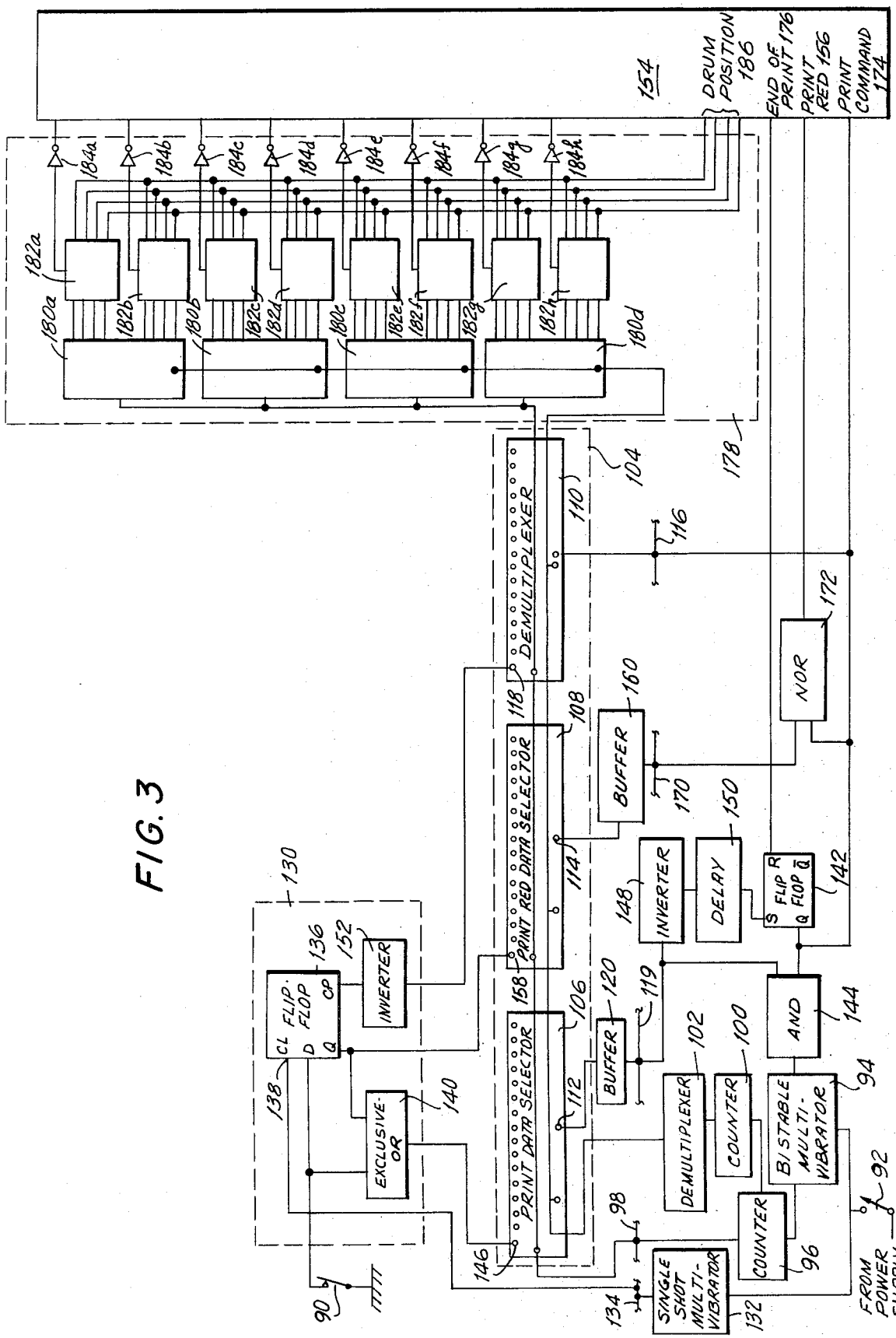

154
DRUM POSITION 186
END OF PRINT 176
PRINT REG 156
PRINT COMMAND 174
184a
184b
184c
184d
184e
184f
184g
184h
182a
182b
182c
182d
182e
182f
182g
182h
180a
180b
180c
180d
178
104
110
116
DEMULTIPLEXER
118
108
PRINT REG DATA SELECTOR
114
BUFFER
160
170
NOR
172
INVERTER
148
DELAY
150
FLIP R FLOP Q
142
130
FLIP FLOP
CL
D
Q
CP
136
152
INVERTER
158
106
PRINT DATA SELECTOR
112
120
BUFFER
119
AND
144
138
EXCLUSIVE-OR
140
DEMULTIPLEXER
102
COUNTER
100
BI STABLE MULTI-VIBRATOR
94
98
COUNTER
96
92
FROM POWER SUPPLY
146
90
134
SINGLE SHOT MULTI-VIBRATOR
132

FIG. 3

FIG. 4A

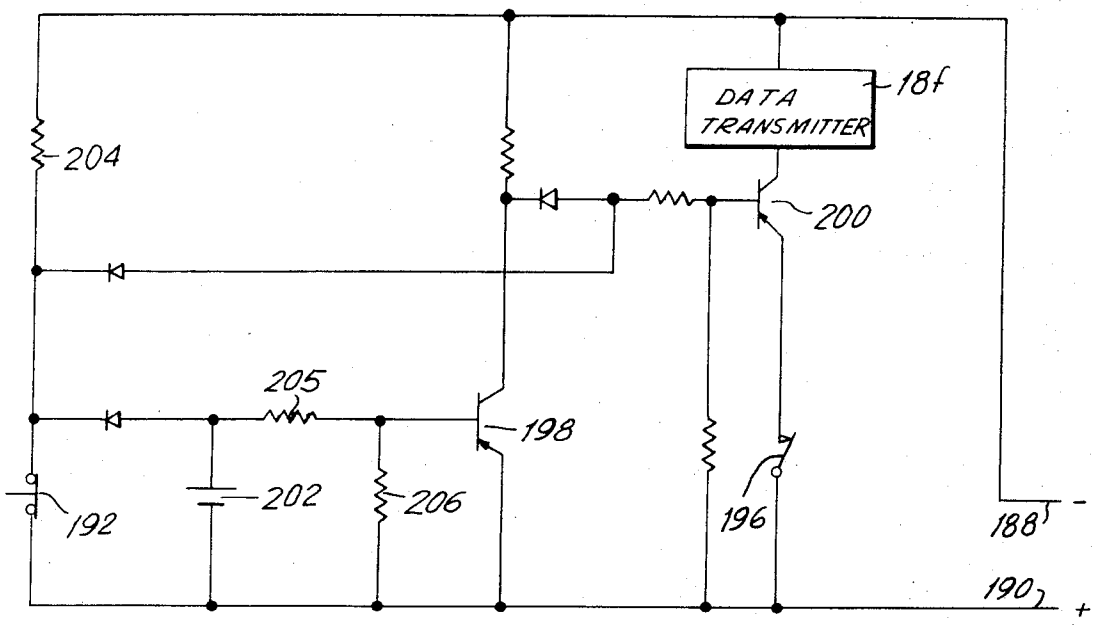
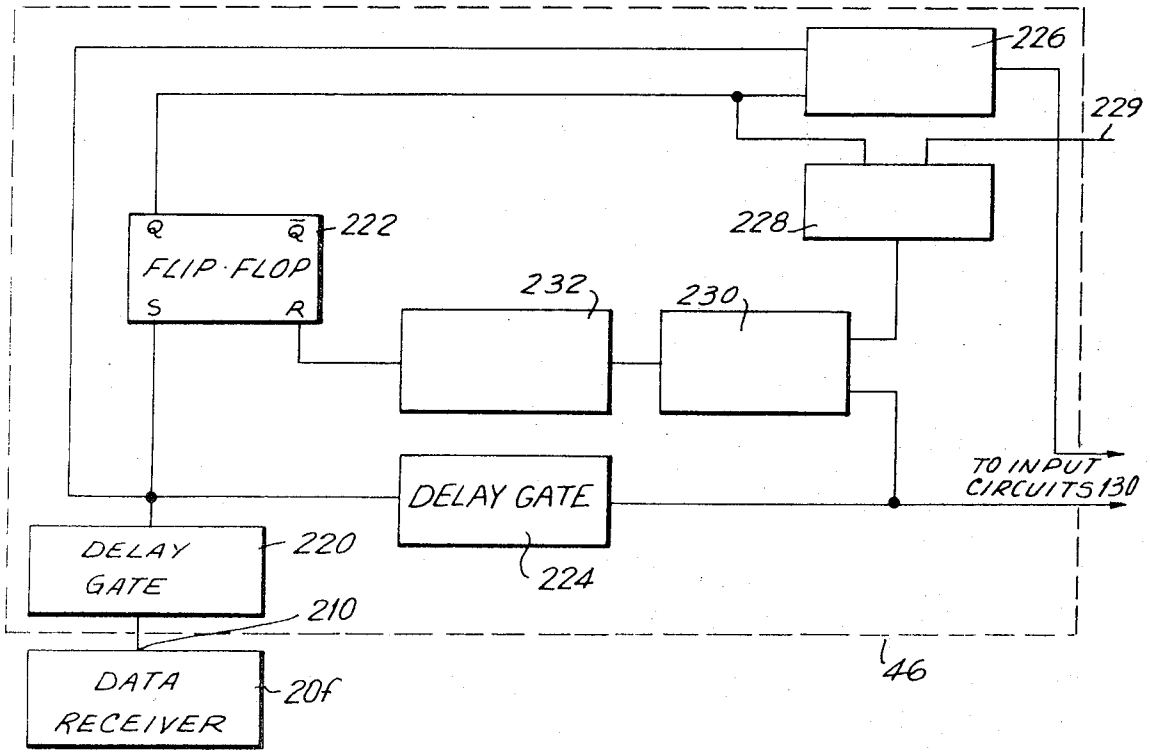

DATA TRANSMITTER
18f
204
200
205
198
202
206
192
196
188
190
-
+

FIG. 4B


226
229
228
Q
$\bar{Q}$
222
FLIP-FLOP
S
R
232
230
DELAY GATE
224
TO INPUT CIRCUITS 130
DELAY GATE
220
210
DATA RECEIVER
20f
46

NONINTERFERING ELECTRICAL SIGNALING

BACKGROUND OF THE INVENTION

The invention relates to electrical signaling systems and, in particular, noninterfering electrical signaling systems used in protection and alarm systems having a central supervisory station and several remote stations.

Electrical signaling systems can be used to remotely monitor the condition of fire alarm boxes, waterflow alarms, burglar alarms, watchman's reporting stations, and industrial process supervisory control systems. These systems can also provide automatic monitoring and control of building environmental conditions. When used as monitoring and control units, the apparatus requires a high degree of reliability.

A variety of techniques have been used in general purpose data transmission electrical signaling systems. These techniques consist of either utilizing a separate transmission path from each monitoring station to a central supervisory station or connecting each of the monitor stations to a frequency and/or time division multiplexing equipment for transmission of their signals over a common data transmission path to the central supervisory station. Monitor stations may include an actuating device to control multiplex transmitting equipment or a transponder which can be interrogated by the central supervisory station. Signals from the transponder indicate the status of an actuating device connected to it. The data signals received at the central station are examined to determine if any deviation from normal exists.

The data transmission path over which the signals are transmitted are often wire conductors. A fault in one or more conductors, such as a break, a short between conductors, or an earth ground of one of the conductors could adversely affect the reliability and operability of the data transmission apparatus.

It is a primary object of the invention to provide a high reliability data transmission system. Another object of the invention is to provide a high reliability data transmission system having input, scanner, and programming circuitry for efficiently recording and outputing information about a multiplicity of monitor stations.

Other objects of the invention are to maintain the integrity of a multiplex data transmission system in spite of a break in the transmission path and to provide a monitor station wherein different time length signals can be transmitted to indicate the status of a plurality of actuating devices.

BRIEF DESCRIPTION OF THE INVENTION

The invention relates to an electrical signaling system which comprises a plurality of monitor stations for transmitting signals in response to the status of a selected condition. The signals are transmitted over a transmission path which interconnects the monitor stations and a supervisory central station. The supervisory central station includes receiving devices for receiving the signals transmitted by the monitor stations. The receiving devices have an output which indicates the status of the selected device.

In one aspect, the invention features input circuits associated with each receiving device. The input has a clocked flipflop connected to the output of the receiving device. The status of the selected condition may be stored by the flipflop. The input circuit also includes an EXCLUSIVE OR gate having inputs from both the flipflop and the receiving device. The output of the EXCLUSIVE OR gate changes in the same fixed direction whenever the output of the receiver circuitry changes.

The supervisory central station further includes a scanning circuit having selectors to sequentially sample the output of the EXCLUSIVE OR gates and demultiplexers to feed back a delayed version of the output of the EXCLUSIVE OR gate in order to clock the flipflop after the EXCLUSIVE OR output has been accepted. The delay is advantageously inserted in the feedback from the selector to the demultiplexer in order to avoid triggering on false signals.

In another aspect the invention features a current sensitive relay connected between the ends of the transmission path whereby the relay is deenergized if there is a break in the conductive path. Under these circumstances, power is supplied to both ends of each conductive path. Circuitry is provided to disconnect the relay from the power source when a break occurs and to momentarily energize the relay when the break is repaired.

Another aspect of the invention features transmitter and receiver time discriminator units whereby a single tone transmitter produces a short turn-off when a momentary switch is actuated and an extended time turn-off when an extended time switch is actuated.

Other objects, features, and advantages will appear from the following description of a preferred embodiment of the invention taken together with the attached drawings in which:

FIG. 1 is a block diagram of an electrical signaling system embodying the invention;

FIG. 2 is a schematic diagram of a line control circuit of the system shown in FIG. 1;

FIG. 3 is a block diagram of the input, scanner, and control circuits of the system shown in FIG. 1;

FIG. 4A is a circuit diagram of the transmitter time discriminator circuit of the system shown in FIG. 1; and

FIG. 4B is a detailed block diagram of the receiver time discriminator circuit of the system shown in FIG. 1.

DESCRIPTION OF A PREFERRED EMBODIMENT

Referring to FIG. 1, power to operate the system is drawn from a power supply 12, for example, a 24 volt rechargeable battery, located at the supervisory central station 14 and isolated from earth ground. The battery is preferably arranged to be trickle charged from locally available 110 volts A.C. power line (not shown). The power supply 12 may also be any other suitable power source which can be isolated from earth ground.

FIG. 1 shows a plurality of monitor stations connected to a transmission path 15, the monitor stations and transmission path being identified in FIG. 1 as line circuit 1. Each monitor station consists of an actuating device and its associated data transmitter or a control device and its associated data receiver. While FIG. 1 shows only one line circuit, a plurality of line circuits may be used and a line control circuit is provided at the supervisory central station 14 for each line circuit. A

line control circuit **16** acts as an interface between line circuit **1** and the remainder of the supervisory central station **14.**

Line control circuit **16** operates to condition the line circuit upon the occurrence of a fault. The operation of line control circuit **16** is described in detail in connection with FIG. **2.**

As mentioned above, each monitor station may include actuating devices associated with data transmitters and control equipment for control devices associated with data receivers. The actuating device may be a contact or contacts and associated circuitry, if any, or a digital output corresponding, for example, to a multiplexed output of a plurality of contacts or an encoded output representing a measured signal value. The data transmitter may be either part of the actuating device or a separate unit and, in either case, operates in response to the status of the condition intended to be monitored by the actuating device. Each data transmitter and its actuating device are connected across transmission path **15,** and the output signal is received by a data receiver at the supervisory central station **14.** The output of the data receiver reflects the operation of the corresponding data transmitter. The output of the data receiver, either directly or through decoding or detector circuitry, describes the condition of one or more actuating devices.

A data receiver may be connected to the transmission path when it is desired to control an operation from the supervisory central station. The control equipment may be a relay which controls heating or cooling equipment. A signal transmitted by a data transmitter at the central station will be received at the remote station and the equipment will respond to the received signal.

The transmission path **15** consists of two conductors which form a loop starting at the line control circuit and returning to the line control circuit. The monitor stations are connected in parallel across the conductors and in this embodiment, the monitor stations receive their power from the transmission path.

Referring to FIG. **1,** data transmitters **18***a*, **18***b*, **18***c*, **18***f*, **18***g*, **18***h* may be of any design suitable to operate over the transmission path and are, in the preferred embodiment, audio resonators combined with line powered exciters and audio amplifiers which continuously transmit a single audio frequency signal unless turned off. The transmitter may be the Line Power Transmitter sold by H. B. Engineering Company of Silver Springs, Md. The data receivers **20***a*, **20***b*, **20***c*, **20***f*, **20***g*, **20***h* can be of any type compatible with the chosen data transmitter and, in the preferred embodiment, are audio resonators combined with an audio amplifier and audio detector. The receivers may be the type manufactured by the H. B. Engineering Company.

Each data receiver and data transmitter in a line circuit operates at a different frequency and the signals are frequency multiplexed over the transmission path. Each receiver detects only the frequency of interest and rejects all other signals.

FIG. 1 shows a variety of actuating devices, control devices, and encoding devices which may be included in a single line circuit. Starting at line control circuit **16,** and working clockwise along transmission path **15,** there is first a noncoded supervisory switch **22***a* controlling data transmitter **18***a*. Switch **22***a* may be any device which provides a normally closed contact, and which opens when the device is actuated. When the contact is closed, associated data transmitter **18***a* is turned on; when the contact is open, associated data transmitter **18***a* turns off. The output of associated data receiver **20***a* varies according to the operation of transmitter **18***a* and the receiver output is monitored by a control circuit **24.** The noncoded supervisory switch may be, for example, a gate valve position indicating switch, a water level detector switch, or a steam pressure supervisory switch.

A plurality of non-coded supervisory switches **22***b*, **22***c*, **22***d* may be connected in series to a data transmitter where it is desired, at the supervisory control central station **14,** to know that one of the plurality of supervisory switches has been actuated, but where it is unnecessary to know which of the plurality of supervisory switches has been actuated. When one of the switches is actuated to the open position, data transmitter **18***b* turns off. The output of data receiver **20***b* reflects this change in condition to control circuit **24.**

When it is necessary to know which of a plurality of non-coded supervisory switches at the same monitor station has been actuated, there are two alternatives. First, the plurality of supervisory switches can be arranged so that each has a separate data transmitter in a manner similar to that shown by non-coded switch **22***a* and data transmitter **18***a*. Second, and preferably, the plurality of supervisory switches may be connected to a multiplex encoder. Referring to FIG. **1,** in the preferred embodiment, multiplex encoder **26** provides a stream of digital data to transmitter **18***c*. The stream of digital data represents the condition of each of non-coded supervisory switches **22***e*, **22***f*, **22***g*, **22***h*, **22***i*, **22***j*, **22***k*, and **22***m*. The multiplex encoder **26** is preferably the pulse code modulated encoder sold by H. B. Engineering Company. The encoder is a solid state scanner which scans each of its inputs at a variable clock rate and provides a data stream output of digital signals. The output signals are bilevel, and the length of time for which the output signal of multiplex encoder **26** is in a given state is indicative of the status of the switch inputs. The output of the data transmitter **18***c* connected to multiplex encoder **26** is received by data receiver **20***c* whose output is connected to multiplex decoder **28.** The multiplex decoder **28** decodes the data stream, which was generated by multiplex encoder **26,** transmitted by data transmitter **18**c, and received by the data receiver **20**c. The decoded data are stored in the decoder's buffer memory which provides an individual output, for each of the non-coded supervisory switches connected to multiplex encoder **26,** to the control circuit **24.** In the preferred embodiment, the multiplex decoder also checks the data stream for errors; and incorrect or erroneous signals are ignored.

In some instances, it is desirable to use a single data transmitter with two non-coded stations but not use a multiplexer. This is possible through the use of a transmitter time discriminator unit **40** which receives inputs from a momentarily operated actuating device such as watch report station **42** and an actuating device which is operated for an extended period of time such as a fire alarm box **44.** When the watch report station is momentarily operated by a watchman, the time discriminator unit turns off data transmitter **18***f* for a short period of time. If, on the other hand, the fire alarm box is actuated, the data transmitter **18***f* is turned off for an

extended period until the fire alarm box is reset. In the preferred embodiment the extended period device can only be manually reset at the monitor station. In order to determine at the receiver, which device was actuated, the times of actuation must not overlap. Thus, the extended time device can be three seconds or longer, and the momentarily operated actuating device can be operated for a time less than the extended time; that is, less than three seconds. The output of data transmitter **18***f* is received by data receiver **20***f*. The output of the data receiver **20**f is interpreted by receiver time discriminator unit **46** to provide an output signal corresponding to each actuating device. Time discriminator circuits **40, 46** are described in greater detail in connection with FIGS. 4A and 4B.

When the signal to be monitored is an analog or continuous signal, as opposed to a two state on-off or switchtype signal, an analog-to-digital converter **48** may be used to convert the analog signal to a digital number. The digital number, represented on the output signal lines of converter **48,** is serially encoded by multiplex encoder **50** for transmission by data transmitter **18***g* over the transmission path. The output of data transmitter **18***g* operates data receiver **20**g which is connected to multiplex decoder **52.** Multiplex decoder **52** converts the serial input to a digital number and the digital number is converted by digital-to-analog converter **54** to an analog signal level. The output of digital-to-analog converter **54** is connected to an analog recording device **56** which may be, for example, a chart recorder.

A control device **58,** for example a relay which is used to shut down air conditioning fans, is operated from data receiver **20***h* when data transmitter **18***h* is turned on. Data transmitter **18***h* may be turned on from any actuating device, for example, a manually operated switch **60,** or the output of any one of the data receivers located at the supervisory control station.

The monitoring stations, that is the data transmitters, data receivers, and, respectively, their associated actuating devices, interface devices, and control devices can be positioned in any sequence along the transmission path. In addition, any data transmitted from a data transmitter located at any point on the transmission path can be received by an associated data receiver located at any other location in the transmission path. This results because the data transmitters and data receivers in the line circuit are connected in parallel.

FIG. **2** shows a preferred circuit arrangement for line control circuit **16.** The line control circuit is so constructed that if a fault occurs in the transmission path, operation and integrity of the system is maintained while lamps and sounding devices (not shown) are provided to alert an operator of the nature of the line circuit fault. The fault may be a break in the transmission path, an earth grounding of one of the conductors forming the transmission path, or a short between the conductors of the transmission path.

FIG. **2** also shows the manner in which data receivers and data transmitters and their associated circuitry, all designated by reference number **61,** are arranged in parallel across the transmission path. The figure also shows that the data transmitters and receivers at the central supervisory station, designated by reference number **63,** are connected in parallel at line control circuit **16** across the transmission path.

In operation, if a break occurs in the transmission path, relay coil **62,** which in normal operation is energized, deenergizes and releases. The transmission path consists of conductive loops **64, 66.** Relay contacts **62***a* and **62***b*, associated with relay coil **62,** are shown in FIG. **2** with coil **62** energized. Thus, when relay coil **62** is deenergized, the relay contact **62***a* closes and relay contact **62***b* changes position so that power is applied to both ends of each conductive loop **64, 66** of the transmission path, thereby ensuring that power is provided to all of the data transmitters and data receivers. At the same time, an additional contact associated with relay coil **62** will light a lamp or energize an alarm to indicate at the central station the nature of the fault. A push button switch having contacts **67***a* and **67***b* is provided so that after the break has been corrected, relay coil **62** can be energized. This resets the circuit to its normal operating condition.

As mentioned above, the power supply **12** is isolated from earth ground in the preferred embodiment. If, therefore, there is an earth ground fault in the transmission path, one or the other side of the D.C. power supply will be near earth ground and relay coil **68,** normally deenergized, will operate and energize. Relay coil **68** is connected in a diode circuit **69,** one side **70** of the diode circuit being connected to earth ground. A relay contact (not shown) associated with relay coil **68** may operate lamp and audible sound alarms to indicate the nature of the transmission path fault.

The line control circuit of FIG. **2** will also detect a short between the two conductive loops. In operation, the current which flows through an adjustable resistor **71** produces a small voltage drop across that resistor. The voltage drop is normal operation is insufficient to cause a transistor **72** to conduct current and, therefore, a relay coil **74** connected to the transistor is not energized. If the current through resistor **71** increases, the voltage drop across resistor **71** increases and depending upon the type and number of reference diodes **76,** transistor **72** will at a predetermined current conduct because its base-emitter junction becomes forward biased. Relay coil **74** will then be energized. Additional contacts associated with relay coil **74** (not shown) are provided to operate lamps and audible alarms to indicate the nature of the line fault. Capacitor **78** is provided to inhibit energization of relay coil **74** where the increased current is of momentary duration. Resistor **80** and coil **82** act to block A.C. signals.

FIG. **3** shows a preferred embodiment of control circuit **24** of the system shown in FIG. **1.** The output of each data receiver, multiplex decoder, or other device, for example, relay contacts, can be represented by an open or closed switch, such as input switch **90** connected to logic "**0**". In normal operation, input switch **90** is in the closed position indicating the normal operating condition at the monitor station. When the condition being monitored deviates from normal, switch **90** would assume an open position. The switch would then assume the closed position when the condition being monitored restores itself or is restored to normal. In a large system, there are a plurality of inputs having an output function equivalent to that of switch **90;** however, for the purposes of illustration, only one input, switch **90,** is shown and described.

When power is applied to the control circuitry by closing a power-on switch **92,** a bistable multivibrator **94** is enabled. The output of multivibrator **94** is applied

to increment a counter **96.** Counter **96** is a four bit binary counter, the four bit output being applied to count bus **98.** The high order bit of counter **96** is applied to increment a counter **100,** also a four bit binary counter. The four bit output of counter **100** is applied to a 4-line to 16-line demultiplexer **102.** For each four bit count of counter **100** (of which there are sixteen), demultiplexer **102** enables one and only one of its sixteen output lines.

The output of demultiplexer **102** enables one of a maximum number of 16 scanner circuits **104.** FIG. **3** shows one of the possible 16 scanner circuits. Each scanner circuit **104** consists of a print data selector **106,** print red data selector **108,** and demultiplexer **110.** Print data selector **106** and print red data selector **108** perform the same function, and may be, for example, Texas Instruments Corp. type SN 74150. These units are enabled by the signal from demultiplexer **102** and once enabled, the signal on the input terminals designated by the count on bus **98** is selected and placed on outputs **112** and **114,** respectively. Demultiplexer **110** performs the reverse function and may be, for example, Texas Instruments type SN 74154. After being enabled by demultiplexer **102,** demultiplexer **110** makes the input from signal acknowledge bus **116** available to the output terminal, for example output terminal **118,** designated by the signal on count bus **98.** Thus, each component of all scanner circuits **104** is connected to the count bus **98.**

As noted, the scanner circuits are sequentially selected by demultiplexer **102.** The varying binary count on the count bus **98** then sequentially connects the inputs of the print data selector for the enabled scanner circuit, one input at a time, to print bus **119** through buffer gate **120.**

Under normal conditions, the input to print data selector **106** from an input circuit **130** will be a logic "**0**". When the power-on switch **92** is closed, applying power to the system, a single shot multivibrator **132** is enabled thereby applying a momentary logic "**0**" to a clear bus **134.** A flipflop **136** of input circuit **130,** preferably a type D flipflop, is connected to the clear bus **134** at its "clear input" **138.** The leading edge of the single shot multivibrator **132** output signal operates to clear flipflop **136** resulting in a logic "**0**" on the Q output. Since the output of switch **90** is normally at logic "**0**", the output of EXCLUSIVE OR gate **140** is also logic "**0**". Thus, under normal conditions, the input to inverting buffer gate **120** is at logic "**0**", and its output will be logic "**1**".

The Q output for flipflop **142,** in the preferred embodiment of the R-S type, is at logic "**1**", so that both inputs to AND gate **144** are at logic "**1**". AND gate **144** thereby has a logic "**1**" output which enables bistable multivibrator **94** as was previously assumed.

When one of the conditions being monitored changes to a logic "**1**", corresponding to opening switch **90,** the output of EXCLUSIVE OR gate **140** changes to logic "**1**". When the input to the print data selector **106** corresponding to a logic "**1**" is selected, the output of the print data selector will change to a logic "**1**", and the output of inverting buffer gate **120** will change to a logic "**0**". One input to AND gate **144** will be a logic "**0**"; and, therefore, the output of AND gate **144** changes to a logic "O", inhibiting further operation of bistable multivibrator **94.** Thus, the scanner **104** is stopped at the input which indicates a deviation from normal condition, input **146.** In addition to temporarily inhibiting further counts from the bistable multivibrator, the output of buffer gate **120** is connected to an inverting gate **148,** the output of which starts delay gate **150** which provides a retard, for example, 60 milliseconds, before enabling its output. The purpose of the retard or delay is to prevent operation of flipflop **142** in the event of momentary false signals. Such false signals may be caused by electrical noise or relay contact bounce. At the expiration of the 60 millisecond delay time, flipflop **142** is set by the output of delay gate **150,** and the Q output goes to logic "**0**". The Q output of flipflop **142** maintains an inhibiting logic "**0**" output to multivibrator **94** through AND gate **144,** so that even if the condition being monitored should return to normal, scanning remains inhibited and a warning message will be printed. The Q output of flipflop **142** is also applied to signal acknowledge bus **116.** The signal acknowledge is applied to inverting gate **152** through demultiplexer **110.** The output of gate **152** clocks flipflop **136,** the Q output of flipflop **136** going to logic "**1**", since the input from switch **90** is at logic "**1**". As a result, the output of EXCLUSIVE OR gate **140** goes to logic "**0**" and the output of buffer gate **120** returns to logic "**1**".

The Q output of flipflop **136** will affect the operation of mechanical printer **154.** In order to alert the operator of a deviation from normal condition, a programmed message is printed by printer **154.** The message will be printed in red to alert the operator that the condition has deviated from normal. A print red command placed on line **156** effects printing in red. The print red data selector **108,** like the print data selector **106** has stopped and has selected an input **158** which corresponds to input **146** of the print data selector. Thus, the Q output of flip flop **136** is connected through selector **108** to buffer gate **160.** The output of buffer gate **160** is connected to print red bus **170,** which is one input of NOR gate **172.** When the Q output of flipflop **136** goes to logic "**1**", as a result of the signal acknowledge signal on bus **116,** the output of buffer gate **160** goes to a logic "**0**". Thus, both inputs to NOR gate **172** are at logic "**0**" and its output goes to logic "**1**". The output of NOR gate **172** is the print red command, line **156,** and whenever the output of NOR gate **172** is at logic "**1**", the mechanical printer **154** will print in red rather than black. In this manner, the first signal corresponding to a condition deviating from normal results in a message printed in red, and, as is described below, a subsequent return to normal will be printed in black.

The printing operation is initiated when the Q output of flipflop **142** goes to logic "**0**", this being a print command on line **174.** The print red command appears an extremely short time after the print command and before actual printing has occurred. When the printing operation has been completed, flipflop **142** is reset by an end of print signal on line **176.** This causes the Q output of flipflop **142** to return to the logic "**1**" state. Since the output of buffer gate **120** is already at logic "**1**", the output of AND gate **144** changes to logic "**1**" and bistable multivibrator **94** begins operation and other inputs are scanned.

There are no further messages relating to the deviation from normal condition that has been reported in red until the condition is restored to normal. At that time, the input from switch **90** returns to logic "**0**" and

the output of EXCLUSIVE OR gate **140** goes to logic "**1**". The sequence of events which follows is substantially the same as when the condition originally deviated from normal since both the original deviation from normal, as well as the subsequent return to normal both cause the output of EXCLUSIVE OR gate **140** to be logic "**1**". While the sequence of events is identical to the sequence which occurs when switch **90** is first opened, the message which indicates a return to normal is printed in black because the Q output of flipflop **136** will be logic "**0**" after it is clocked by a signal derived from the signal acknowledge signal on bus **116.** After the mechanical printer **154** prints the message in black, the end of print signal causes flipflop **142** to reset and enables bistable multivibrator **94** through AND gate **144** and scanning continues.

Printer **154** may be any type compatible with the control circuit, and in the preferrd embodiment is a Keltron Corporation type Dm-400 Digiprinter. The input to the printer can be programmed so that printer **154** prints specific alphabetic and numeric characters in desired positions in a line. For example, by providing the appropriate input signals, the printer can print FIRE 7253 in either red or black characters. The inputs to the printer are received from programmer circuit **178.** FIG. **3** shows one section of the programmer circuit corresponding to the scanner circuit **104** shown in FIG. **3.** In a larger system there will be as many more programmer sections as there are scanner sections, and the outputs of the programmer circuits will be tied together in parallel. The programmer circuit includes programmable read-only memory **180***a*, **180***b*, **180***c*, **180***d*, for example, Signetics Corporation Type 8Z23; comparators **182***a*, **182***b*, **182***c*, **182***d*, **182***e*, **182***f*, **182***g*, **182***h;* and inverting gates **184***a*, **184***b*, **184***c*, **184***d*, **184** *e*, **184***f*, **184***g*, **184***h*. In the preferred embodiment, the comparators are four bit comparators. The circuit is arranged to print an eight character message, foru alphabetic characters followed by four numerals.

In operation, the output of each programmable readonly memory is determined by the binary count bus **98** and the demultiplexer **102** output. Thus, the program circuit **178** of FIG. **3** represents one of sixteen possible program circuits and is the one which corresponds to scanner circuit **104.** The output of binary counter **96** and the signal from demultiplexer **102** uniquely define which actuating device is being monitored, and the outputs of memories **180***a*, **180***b*, **180***c*, **180***d* will define the message corresponding to that device. If the condition being monitored is in the normal range, the Q output of flipflop **142** is at logic "**0**"and a message is not printed. When a deviation from normal occurs, the Q output of flipflop **142** goes to a logic "**1**", and the print command is given.

The eight bit output of each read-only memory represents two **4** bit words, each four bit word representing a numeric or an alphabetic character. The alphabetic or numeric characters have been pre-programmed into the read-only memories at some earlier time and determine the unique message corresponding to the condition being monitored. During printing, each four bit word is compared by the comparators with the output of the print drum on lines **186.** When the print drum position agrees with a four bit work output of one or more of the read-only memories, the corresponding comparators enable their output lines which, through the corresponding inverting gates, cause the corresponding print solenoids to operate and print desired characters of the message. After the print drum has made a complete revolution so that all of the alphanumeric characters on the drum can be selected, the message is completed and an end of print signal is given over line **176.** As noted above, the end of print signal resets flipflop **142,** and allows the system to continue scanning.

It may be desirable not to print a character in one or more positions of the message. In that instance, circuitry exists in printer **154** to recognize a binary "**1111**" from the memory and to thereby inhibit printing in that position even if the comparator output is enabled.

FIG. **4A** shows the transmitter time discriminator unit **40** of FIG. **1** in greater detail. Transmitter unit **40** and data transmitter **18***f*, rather than being distinct units, are integrally related. Connection to the transmission path, from which power is received is made at terminals **188** and **190.** Referring to FIG. **4A** momentary actuating device **192** may be a pushbutton switch or any other momentary switch such as found at watch report station **42.** In normal operation, the actuating device **192** presents a closed circuit. Extended time actuating device **196** may be any normally closed switch which, when opened, remains open for an extended period of time, for example, longer than 3 seconds. This may correspond to a switch at fire alarm box **44.**

The transmitter time discriminator unit is particularly useful when a watch report station and a fire alarm box are integral to the same unit. In operation, transistor **198** is normally in a non-conducting or off state, and transistor **200** is normally conducting or on. Data transmitter **18***f* is normally on. When momentary actuating device **192** opens, capacitor **202** charges through resistor **204** and, after a predetermined time, the base-emitter junction of transistor **198** becomes forward biased sufficiently to cause transistor **198** to turn on. Thus, shortly after momentary device **192** is opened, both transistors **198** and **200** are turned on. When momentary device **192** closes, transistor **198** remains on for an amount of time determined by the discharge of capacitor **202** through resistors **205, 206** and the base of transistor **198.** Transistor **200** will turn off when device **192** closes until transistor **198** turns off. When transistor **200** turns off, the data transistor **18**f will also turn off. After the predetermined amount of time, the circuit returns to its normal condition with capacitor **202** substantially discharged. Thus after momentary device **192** is actuated and released, data transmitter **18***f* turns off for a predetermined short amount of time. When extended time device **196** is opened, data transmitter **18***f* turns off immediately and remains off for as long as device **196** is open, a time longer than the above mentioned "predetermined short amount of time."

FIG. **4B** shows the receiver time discriminator circuit **46** and data receiver **20***f* in more detail. When data transmitter **18***f* turns off, the associated data receiver **20***f* also turns off and output **210** of data receiver **20**f, normally at logic "**0**", thereby starts a delay gate **220,** for example a 60 millisecond delay. This delay prevents electrical noise or sporadic contact closure from triggering the circuit. At the end of 60 milliseconds, the output of delay gate **220,** normally logic "**0**", is enabled to a logic level "**1**". This sets a flipflop **222** and starts a second delay gate **224.** Flipflop **222** is preferably of the R-S type. Delay gate **224** may be of any relatively

long delay time, and is preferably 3 seconds, corresponding to the minimum open time of actuating device **196.** The Q output of flipflop **222** goes to logic "**0**". If the momentary device **192** had opened, transmitter **18***f* will turn off, for example, for 500 milliseconds, and data receiver **20***f* turns back on after 500 milliseconds causing delay gate **220** to inhibit the output of delay gate **224** before it is enabled to logic "**1**". The inputs to a NOR gate **226** are both now at logic "**0**", so that gate **226** provides a logic "**1**" as an input to a circuit **130.** When printer **154** responds with the end of print signal over line **176,** the inverse of that signal is applied to a NOR gate **228** over line **229.** The output of NOR gate **228** changes to logic "**1**". A NOR gate **230** thereby provides a logic "**0**" signal to an inverter **232,** the output of delay gate **224** being at logic "**0**", and flipflop **222** is reset with the Q output returning to logic "**1**".

If the extended time actuating device **196** had opened, data receiver **20***f* turns off and delay gate **220** is started as before. At the expiration of 60 milliseconds, delay gate **224** is started and flipflop **222** is set again as before. After 3 seconds, the delay gate **224** provides a logic "**1**" to one of the plurality of input circuits **130** described in conjunction with FIG. **3** and also provides a logic "**1**" to NOR gate **230** to reset flipflop **222,** through inverter **232.** When the data receiver turns on following the reclosing of device **196,** gates **224** and **220** turn off so that the signal to the input circuits **130** turns off.

It should be appreciated that the time discriminator units of FIGS. **4**A and **4**B are not capable of indicating simultaneous operation of both actuating devices. Thus, priority is given to the extended time device, so that if it is actuated the momentary closure of device **192** will be lost. As a practical matter, this is of little importance since, as previously explained, the extended time device is usually used for fire alarms, and the circumstances requiring its usage would preempt the routine watch report signal. Further, the transmission of a fire alarm signal would have the same effect as a watch signal, i.e., an indication that the watchman is present on the scene.

The momentary closure of device **192** may be lost in another instance. If, after flipflop **222** is set and data receiver **20**f turns on, an end of print signal acknowledging a different input occurs, then flipflop **222** will be reset and no record of the momentary signal will remain. In order to prevent this loss of data, the end of print signal can be gated by circuitry which allows only the end of print signal corresponding to the momentary device input to reset flipflop **222** through gate **228.**

Other embodiments will occur to those skilled in the art and are within the following claims.

What is claimed is:

1. An electrical signaling system comprising a plurality of monitor stations for transmitting signals in response to the status of a selected condition,

a supervisory central station,

at least one transmission path interconnecting said monitor stations and said supervisory central station,

said supervisory central station including

a plurality of receiving devices connected to said transmission path for receiving the signals transmitted by said monitor stations, said receiving device having an output to indicate the status of the selected condition and

at least one input circuit associated with each receiving device and connected to the output of the receiving device,

said input circuit having a clocked flipflop connected to said output to store the status of the selected condition, and

an EXCLUSIVE OR gate having as inputs, the flipflop and the output of the receiving device, the EXCLUSIVE OR gate having an output signal connected to a scanning circuit to indicate a change in the status of the selected condition.

2. The electrical signaling system of claim **1** in which said scanning circuit includes

at least one selector circuit having inputs to receive the output signal from the EXCLUSIVE OR gate, and

at least one demultiplexer circuit to feed back a delayed version of the output signal to clock the flipflop.

3. The electrical signaling system of claim **2** including means for sequentially scanning the inputs of the selector circuit and means for inhibiting sequential scanning when the output signal indicates a change in the status of the condition.

4. The electrical signaling system of claim **3** including a printer and

a programmer circuit for causing the printer to print a message corresponding to the condition at which the sequential scanner was inhibited.

5. A multiplex electrical signaling system comprising

a plurality of monitor stations,

a supervisory central station,

at least one transmission path including two conducting paths interconnecting said monitor stations and said supervisory central station, each conducting path having first and second ends,

each conducting path looping out from the supervisory central station and returning back to the central station,

said central supervisory station including a current sensitive relay coil connected to one end of each of said pair of conductive paths, the other ends of said conductive paths being connected to a source of power,

said relay coil having associated with it contacts, the contacts being arranged to supply power to both ends of the conductive path at the supervisory central station when the coil is deenergized.

6. The multiplex electrical signaling system of claim **5** including a circuit means to disconnect said relay from the power source when the coil is deenergized and a switch to momentarily supply energizing current to the relay coil whereby the relay coil will be reset.

7. The multiplex electrical signaling system of claim **6** further including short circuit control means connected across the transmission path to detect a decrease in the impedance between the two conductors, said means including

a transistor having an emitter, base, and collector,

the collector being connected to one side of the source of power through a current sensitive device,

the emitter being connected to a second side of the source of power through a predetermined voltage drop,

and a resistor between the emitter and base, the base being connected to the transmission path whereby a voltage is produced between the base and emitter in proportion to the current between the two conductors.

8. The multiplex electrical signaling system of claim **7** wherein the current sensitive device is a relay.

9. The multiplex electrical signaling system of claim **6** wherein the source of power is isolated from earth ground, and further including an earth ground control for indicating when there is a short between earth ground and the transmission path, said earth ground control including a relay coil having one terminal connected to earth ground and the other terminal connected through impedances to both sides of the source of power.

10. An electrical signaling system comprising

a plurality of monitor stations,

a central supervisory station,

at least one transmission path including two conducting paths interconnecting said monitor stations and said central supervisory station,

said monitor stations including a transmitter time discriminator for providing an indicating signal of short time duration when a momentary actuating device is operated, and an indicating signal of long duration when an extended time actuating device is operated.

11. The electrical signaling system of claim **10** wherein said monitor station includes a single tone transmitter, said transmitter being turned off when the extended time actuating device is operated, and being turned off for a predetermined short time after actuation of the momentary actuating device.

12. The electrical signaling system of claim **11** wherein the transmitter time discriminator includes a first transistor, the transmitter being connected to a collector of the first transistor and the extended time actuating device being connected to an emitter of the first transistor, the first transistor being normally turned on when the extended time actuating device and the momentary actuating device are closed.

a second transistor, first circuit means to connect a collector of the second transistor to the base of the first transistor, the momentary actuating device being in a base circuit of the second transistor, a timing capacitor resistively connected to the base of the second transistor, the momentary contact being connected across the capacitor in the base circuit of the second transistor so that the capacitor charges to turn on the second transistor, when the momentary switch is opened, whereby the capacitor discharges partially through the second transistor when the momentary actuating device is closed and the first transistor is held for a short time while the second transistor is on and the momentary actuating device is closed.

13. The electrical signaling system of claim **12** including a receiver time discriminator for distinguishing two signals from the transmitter time discriminator and for producing two signals which indicate the status of the devices at the monitor station.

14. The electrical signaling system of claim **13** wherein said receiver time discriminator includes a delay device having a delay time corresponding to the minimum time actuation of the extended time contact, said delay device being connected to receive a delayed version of the signal output of the data receiver.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,821,479 Dated June 28, 1974

Inventor(s) Donald W. Campbell

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the title, insert "SYSTEM" after "SIGNALING".

As the inventor, the name "David" should be "Donald".

In the abstract, line 15, the word "dircuit" should be "circuit".

In the abstract, line 16, the word "cofresponing" should be "corresponding".

Column 6, line 34, the word "is" should be "in".

Column 8, line 65, the word "has" should be "had".

Column 9, line 19, the word "Dm-400" should be "DM-400".

Column 9, line 38, the word "foru" should be "four".

Signed and sealed this 26th day of November 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

USCOMM-DC 60376-P69
* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334